Use of a Spin-Labeled Cerebrospinal Fluid Magnetic Resonance Imaging Technique to Demonstrate Successful Endoscopic Fenestration of an Enlarging Symptomatic Cavum Septi Pellucidi

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Key words
- Arterial spin labeling
- Cavum septi pellucid
- Cerebrospinal fluid
- Hydrocephalus
- Magnetic resonance imaging
- Time-spatial inversion pulse labeling

Abbreviations and Acronyms
CSP: Cavum septi pellucidi
CSF: Cerebrospinal fluid
CT: Computerized tomographic scan
MRI: Magnetic resonance imaging
time-SLIP: Time-spatial labeling inversion pulse

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OBJECTIVE: **The aim of this study was to noninvasively visualize whether cerebrospinal fluid (CSF) compartments are in communication.**

CASE DESCRIPTION: **An enlarging cavum septi pellucidi (CSP) produced progressive hydrocephalus following subarachnoid hemorrhage. We questioned what were the dynamics of CSF flow that led to enlargement of the CSP.**

CONCLUSION: **With this case report, we show the usefulness of a newly described magnetic resonance imaging time-spatial labeling inversion pulse technique to establish that an enlarging CSP was the cause of progressive hydrocephalus and that the hydrocephalus was successfully endoscopically treated when the CSP was fenestrated into the ventricular system, establishing communication between the two CSF compartments.**

INTRODUCTION

A recent report from our group has shown that it is possible to noninvasively visualize cerebrospinal fluid (CSF) movement using a modification of magnetic resonance imaging (MRI) arterial spin labeling referred to as time-spatial labeling inversion pulse (time-SLIP) (15, 16). Using this technique, it is possible to determine by noncontrast MRI alone as to whether CSF compartments are in communication. This case report is an example of the usefulness of the time-SLIP technique to show that an enlarging cavum septi pellucidi (CSP) was responsible for progressive ventricular enlargement, and that by endoscopically communicating the CSP into the third and lateral ventricles, the hydrocephalus was successfully addressed.

CASE REPORT

A 44-year-old man developed a sudden headache followed by loss of consciousness. No focal neurological deficit was present. A computerized tomographic (CT) scan showed diffuse subarachnoid hemorrhage (**Figure 1A**) and blood in the lateral, third, and fourth ventricles (**Figure 1B**). Three-dimensional CT angiography showed dilatation of the right vertebral artery consistent with a dissecting cerebral artery aneurysm (**Figure 1C**). A ventriculostomy was placed followed by rapid improvement in his neurological function. A catheter angiogram confirmed the presence of the aneurysm, which was then endovascularly obliterated. Because the patient was able to circulate CSF adequately, the ventriculostomy was removed. A CT scan done 2 months later showed no increase in the size of the ventricles or the CSP, and his neurological function had returned to his prehemorrhagic state. A CT scan 4 months after the subarachnoid hemorrhage showed a mild increase in ventricular and CSP size (**Figure 2A**). Because the patient was asymptomatic, no surgical intervention was undertaken. Six months after the bleed, he began to complain of persistent headaches. A CT scan showed progressive expansion of the CSP and ventricular enlargement (**Figure 2B**). An MRI study, done using a time-SLIP method, showed the flow of CSF between the third and both lateral ventricles, but not into the CSP (**Figure 3**) (see **Supplemental Video 1**, available online, which demonstrates the CSF communication between the third ventricle and the lateral ventricle, but not to the CSP).

An endoscope was introduced into the frontal horn of the right lateral ventricle, and the bowed right septum pellucidum was fenestrated and the cavum entered (**Figure 4A**). A membrane with hemosiderin deposition on the floor of the cavum (**Figure 4B**) was observed, and, when fenestrated, the third ventricle was visualized (**Figure 4C**) (see Supplemental Video 2, available online, which demonstrates an operative view of fenestration of the CSP). A post-fenestration MRI using time-SLIP showed a decrease in the size of the ventricles and the CSP, with CSF communication established between the third ventricle and the CSP (**Figure 5**) (see Supplemental Video 3, available online, which demonstrates the CSF communication between the third ventricle and the CSP). The patient became clinically asymptomatic soon after the fenestration.

DISCUSSION

A CSP is more commonly found in infants and becomes less common when reaching adulthood, where the incidences is about 1% (8, 9). Shaw classified CSP into those

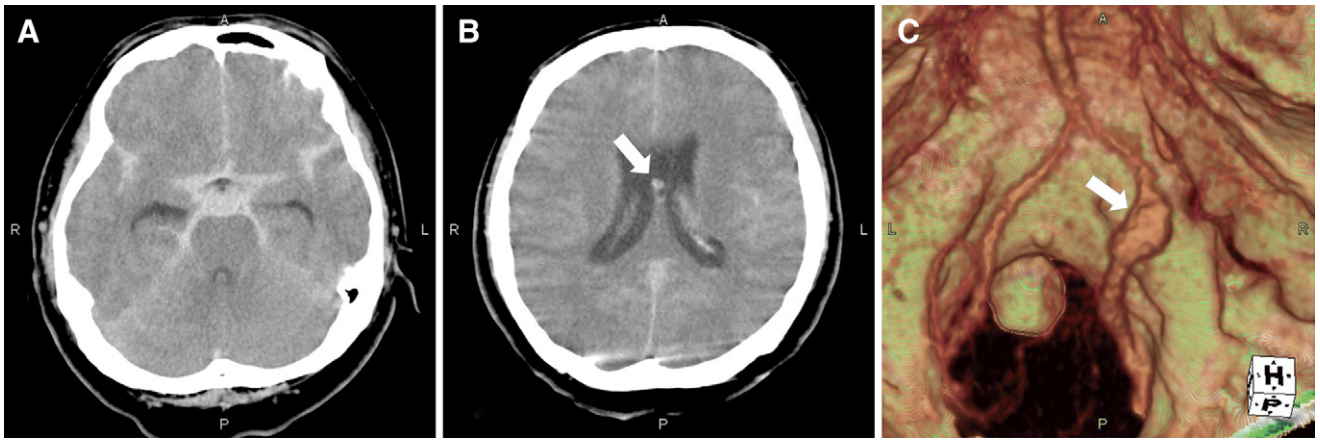

Figure 1. (**A**) Computerized tomographic scan on admission shows diffuse subarachnoid hemorrhage in the basal cisterns and subarachnoid space, and (**B**) reflux of blood into the lateral ventricles and the cavum septi pellucidi (*arrow*). (**C**) Computerized tomographic angiogram revealed a right vertebral artery dissecting aneurysm (*arrow*).

that are asymptomatic and incidental and a second group that are symptomatic and expanding (14). It has been postulated that an asymptomatic nonexpanding CSP was in free communication with the ventricular system, whereas a symptomatic enlarging CSP did not have such a communication. Time-SLIP MRI has noninvasively confirmed this hypothesis, at least in the patient presented.

It is presumed that the asymptomatic CSP, initially seen on the first CT scan at the time of arterial hemorrhage, was in communication with the ventricular system and that the inflammatory reaction from the blood resulted in a membrane formation isolating the CSP. This was then followed by expansion of the CSP, which in turn blocked CSF flow at the foramina of Monro, leading to progressive symptomatic hydrocephalus.

Video available at WORLDNEUROSURGERY.org

Why does the CSP expand once the pathway for free CSF flow between the CSP and the ventricular system ceases to exist? The pathophysiology leading to enlargement of these cysts has been thought to be similar to that for arachnoid cysts with three mechanisms being suggested (2–6, 11–13). The first is that fluid is being produced by the wall of the cyst (1, 7). The second is that an osmotic pressure gradient develops secondary to a higher protein content in the cyst, thereby drawing fluid into the cavum causing it to enlarge (10). The third is that a one-way ball valve mechanism forces fluid into the cyst with arterial pulsations. The time-SLIP MRI study of this patient showed no evidence of such a ball valve mechanism.

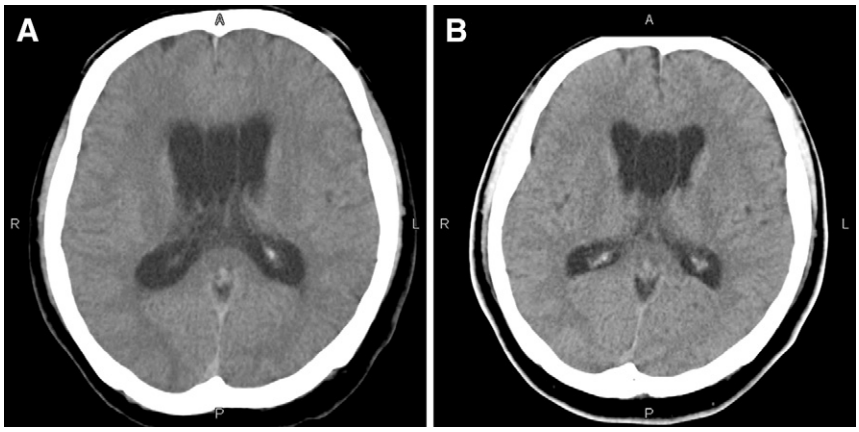

Figure 2. (**A**) Computerized tomographic scan 2 months after the subarachnoid hemorrhage revealed mild ventriculomegaly associated with slight expansion of the cavum septi pellucidi. (**B**) Computerized tomographic scan 6 months after the hemorrhage shows further cavum septi pellucidi expansion.

The ideal tracer to study CSF movement is CSF itself. Using MRI with time-SLIP it is possible to repeatedly visualize CSF movement noninvasively in the clinical setting. One can pulse-label a variable volume of CSF in any orientation in any place in the central nervous system. The acquisition time is short, averaging 3 minutes per scan. Repeated studies are readily doable and can assess CSF movement under normal physiologic conditions as well as in altered states.

The method described was originally derived from arterial spin labeling of blood flowing in vessels. With modification, it became possible to mark (tag) any given volume of blood repeatedly in any orientation. This technique, referred to as time-SLIP, was further modified to visualize CSF bulk and turbulent flow. A nonselective inversion recovery pulse inverts all signals in a field of view from the initial longitudinal magnetization (+) to (−). Immediately after the inversion, a second spatially relative inversion pulse is applied to invert (tag) only the magnetization in the region of interest. The magnetization in the marked region is restored